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# Locating Open Channels: Computer Program for Calculating Excavation Volumes

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# Locating Open Channels: Computer Program for Calculating Excavation Volumes[1]

J. R. Hoover[2]

## INTRODUCTION

Among the problems facing the engineer who designs open channels is the laborious task of computing the volume of earth to be excavated. This volume is presently determined by plotting the survey points and connecting consecutive points with straight lines to form cross sections. The cross sections are composed of the existing and design sections, illustrated in figure 1, which are the actual cross-section shape before construction and the proposed cross section (usually trapezoidal in shape), respectively. The cross-sectional area (cross-hatched in fig. 1) is then determined by planimetering the total area lying above the design section and between the existing and design sections.

To compare the excavation yardages when the centerline of the channel is at different locations, the engineer must plot a new cross section and planimeter the area to be excavated for each proposed centerline location. Therefore, selection of the channel location when straightening is desired at minimum excavation cost can be quite laborious and time consuming, factors that imply a higher design cost. This problem is ideal for solution by a digital computer, and in this paper a programmed solution is presented.

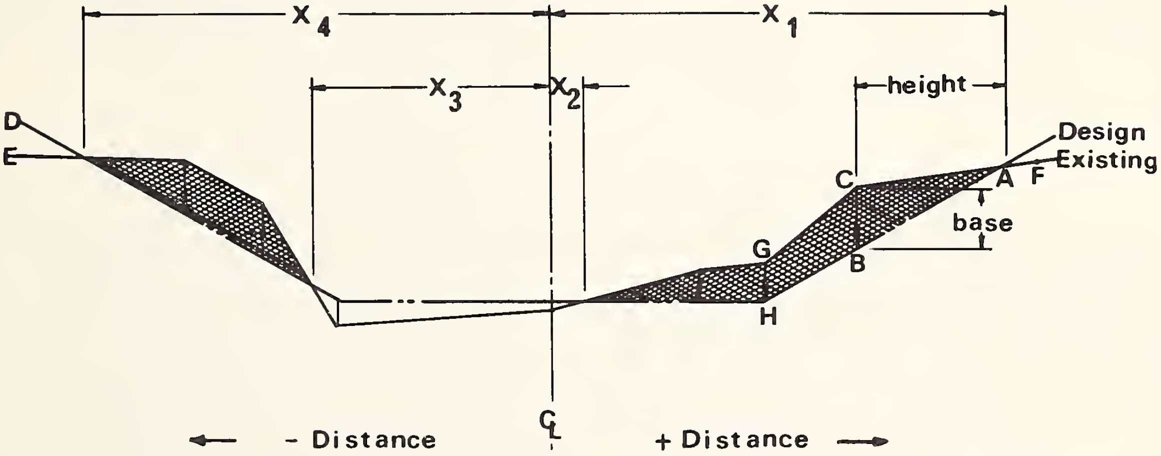

Figure 1.–Subdivision of a cross section for digital computer calculations.

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[2] Agricultural engineer, Soil and Water Conservation Research Division, ARS, USDA, at Brookings, S.Dak. (formerly at Columbus, Ohio).

## OBJECTIVES

The objectives of this study were to develop and test the accuracy and efficiency of a programmed solution as compared with conventional, manual computations of excavation volumes and to obtain operational information on the program's assets (including savings in time, labor, and cost). Ease of submitting to the computer several channel centerline locations, representing different methods of channel straightening, will enable the design engineer to select the channel centerline location that results in minimum excavation cost.

## PROCEDURE

A Fortran program was designed for an IBM-360 digital computer for the purpose of calculating the volumes of earth that must be excavated for open channel improvements (deepening and straightening). The program requires the engineer to establish the design grade, side slope, bottom width, and proposed centerline location. The computer is programmed to determine the grade elevation (channel bottom elevation) at each station (location of a cross section), to generate the design cross section, to compute the cross-sectional area, and to determine the volume to be excavated and cost of the excavation.

To test the computer program, the researcher used survey data accumulated prior to the construction work on the Wabash River, part of the Upper Wabash Flood Control Project near Fort Recovery, Ohio, and the McGurer Ditch located near Columbus, Ohio. Data consisting of the survey data and researcher-established design grade, side slope, bottom width, and proposed centerline location were submitted to the programmed computer, which determined the grade elevation at each station, generated the design cross section, computed the cross-sectional area, and determined the excavation volume and cost of the excavation. For comparative purposes, the researcher also obtained information on the standard manual method of computing excavation volumes (by plotting and planimetering cross sections at each station) so that evaluations of accuracy, time requirements, and cost could be made for both the manual and the computer program methods.

## DESCRIPTION OF COMPUTER PROGRAM

The programmed calculation of the excavation volume is based on the area lying above the design section and between the existing and design sections. Survey data are supplied as distances from the survey base line. The base line to channel centerline distance is supplied by the engineer. The computer converts the surveyed distances to distances from the channel centerline. The survey points are sorted by the computer according to deceasing distances; the points on the left side of the channel centerline are stored in the computer as negative distances. Thus, the keypunching may be in any order for any given cross section. If two points have the same location (vertical rise or cliff), they must be punched in the correct sequential order, progressing away from the baseline. If the existing section survey data are not supplied for distances equal to one-half the proposed bottom width from the channel centerline, the computer interpolates the elevation for these points and inserts them into the survey data in storage. For each survey point of a cross section, a design elevation is generated. The computer determines whether survey points extend far enough on each side of the centerline to intersect the design section, thereby enclosing an area to be calculated. If the survey points do not extend far enough, a message indicating that insufficient field data are available will be printed and the cross section will be ignored. The computer then reads the data for the next station and proceeds with the calculations, computing the volume as though the ignored data had not been included. If necessary, the survey crew can obtain the needed information and the data can be resubmitted to the computer for computation of the desired cross-sectional area.

In calculating the cross-sectional area, the computer compares the existing elevation with the design elevation, progressing from right to left with consecutive data points for the cross section. When two consecutive points (F and C in fig. 1) lie below and above the design section, the computer, using simultaneous linear equations, solves for the distance from the centerline to the point of intersection ($X_1$ in fig. 1). The triangular area ($\triangle ABC$ of fig. 1) above the design section, enclosed by the vertical line through the existing section data point (C) and by the intersecting existing and design sections, is determined. The remaining parts of the cross-sectional area are divided into trapezoids or triangles. The cross-sectional area at each station equals the sum of the areas of all these triangles and trapezoids.

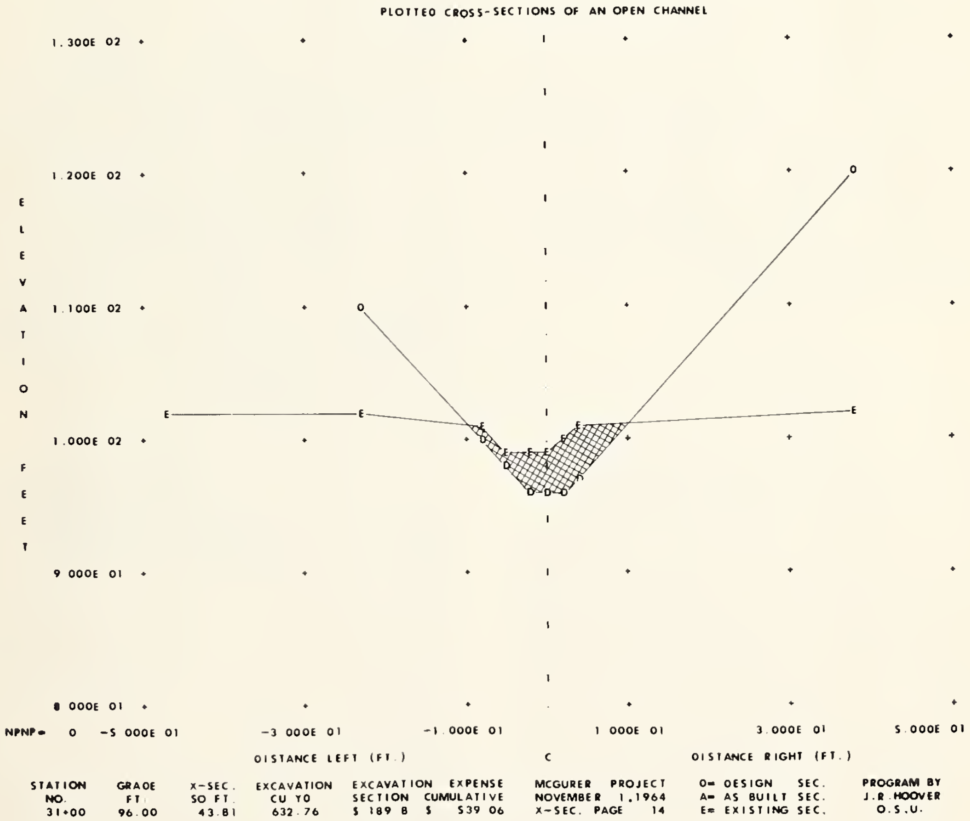
The excavation volume is the product of the distance between consecutive cross sections and the average of the two consecutive cross-sectional areas. After the excavation volume is computed, the cost of excavation between sections and the accumulated cost are determined. The output consist of the station number, design grade, cross-sectional area, excavation volume, section cost, accumulated cost, project name, and the date printed on a plotting of the existing, design, and as-built sections. The as-built is the cross section as it has been constructed. The data for the next section are read into the computer and the same process is repeated.

## RESULTS

A typical cross section of one station (fig. 2) shows an example of the computer-plotted data and results. For illustrative purposes, the letters have been joined by lines and the area to be excavated has been crosshatched. The design section is indicated as plotted D's, the existing section as plotted E's, and the as-built section as plotted A's (not shown). The actual survey point lies somewhere within the smallest rectangle that would enclose the plotted letter. However, the computation of the excavation area is a numerical solution and does not use these plotting positions. The ordinate and abscissa scales are selected to fit the cross-section plot on the page.

These scales are represented as a power of ten. For example, the number 1.300 E 02 means 1.300 × $10^2$ or 130. Negative distances refer to distances to the left of the centerline. The information in figure 2 is self-explanatory, except for the "NPNP =" in the lower left corner of the plot. The letters NPNP refer to the number of points not plotted because they are outside of the plot area.

The important part of figure 2 is the numerical data across the bottom of the plot page. Within the last three printed rows are the identification and the computed results of cross-sectional area, excavation yardage, and cost values.



```
STATION     GRADE    X-SEC.    EXCAVATION   EXCAVATION   EXPENSE     MCGURER   PROJECT    O= DESIGN   SEC.     PROGRAM BY
  NO.        FT.     SQ FT.      CU YD      SECTION    CUMULATIVE    NOVEMBER  1,1964     A= AS BUILT SEC.     J.R HOOVER
 31+00      96.00     43.81      632.76     $ 189 B   $    539 06    X-SEC.  PAGE   14    E= EXISTING SEC.       O.S.U.
```

Figure 2.–Plotted cross section of an open channel.

The most important result of the experimental programming was the accuracy with which the computer calculated the excavation volume. This result was especially evident in the accuracy with which the computer determined the cross-sectional areas of the test channels. For purposes of comparison, an experienced Soil Conservation Service technician provided manual plottings and planimetered areas of 24 cross sections of the channel from the Upper Wabash Flood Control Project in Ohio. The manually determined cross-sectional areas thus obtained were, on the average, within 2 percent of the cross-sectional areas provided by the computer.

Other results of the experiment indicate that the program can effect substantial savings in time, labor, and cost in determining excavation volumes for open channels.

## DISCUSSION

### Program Limitations

If the survey points do not extend far enough on each side of the proposed centerline to intersect the design section, a message indicating that insufficient data were taken will be written and the section will be ignored. In such a situation, the manual method would also fail to obtain the cross-sectional area.

This program is suitable for trapezoidal design sections. For sections that contain a berm, the trapezoidal area above the berm would have to be added to the computed value to correct the cross-sectional area.

The source language for the program is Fortran IV, which is suitable for IBM-360 computers. The Fortran source statements are included in appendix A and the flow chart for the program is given in appendix B. The program uses a plotting subroutine called OHC PLOT, cataloged as "Fort Lib 08.6.01" by the Ohio State University. The University obtained this plotting subroutine from Share, a company that develops and sells computer programs to computer centers.

### Program Assets

#### *Flexibility*

Many properties providing for flexibility have been introduced into the program to make it adaptable to a variety of conditions. Most of these flexibilities are controlled by the input data for each individual station. Specifications for the input data are given in appendix C and an example of input data is presented in appendix D. For example, these specifications detail how several channels can be computed consecutively, with a separate calculation for the volume and cost of each. The program also permits an abrupt change in grade, bottom width, side slope, and cost per cubic yard at any given station, inasmuch as this information is read in on the station number card. Most important, the computer will interpolate the elevation values at the toe of the proposed side slopes if necessary. Therefore, the location of the channel centerline can be shifted by changing one control card specifying the desired distance between the centerline and the surveyor's base line. This feature makes the program suitable for comparing cross-sectional areas of alternate locations of the channel centerline. This last feature implies that the engineer can use the program to evaluate the construction cost for alternate centerline locations. This is in addition to the basic feature of computation of the payment owed the contractor for completed channel improvements.

#### *Increased Accuracy*

The increased accuracy with which the digital computer calculates excavation volumes has already been discussed. The computer improved accuracy by determining the intersection points and all the area, volume, and cost calculations by exact algebraic methods. The manual method, on the other hand, introduces human error in plotting and planimetering the cross section, thus generally limiting the plotting and calculation accuracy to approximately 95 to 99 percent, according to the magnitude of the errors. Nonuniformity of paper surface, grid size, and so forth also contribute to errors in the planimetering process.

#### *Savings in Time, Labor, and Cost*

The manual method of plotting and planimetering is laborious and requires approximately 30 minutes per cross section, depending on the amount of field data taken. Assuming that a technician whose wage is $3 per hour can plot and planimeter 15 cross sections per 8-hour day, the cost of determining the cross-sectional area at each station will be $1.60 per cross section. In comparison, the computer calculated the cross-sectional area of the same 15 stations in 0.1 of a minute. If computer time cost $9.20 per minute (6 cents per cross section), and the 15 cross sections can be keypunched in 12 minutes by the above technician (4 cents per cross section), the total cost will be 10 cents per cross section. Therefore, the computer program results in greater accuracy at a cost reduction of 94 percent.

# APPENDIX

## A. Program Source Statements (Fortran IV Language)

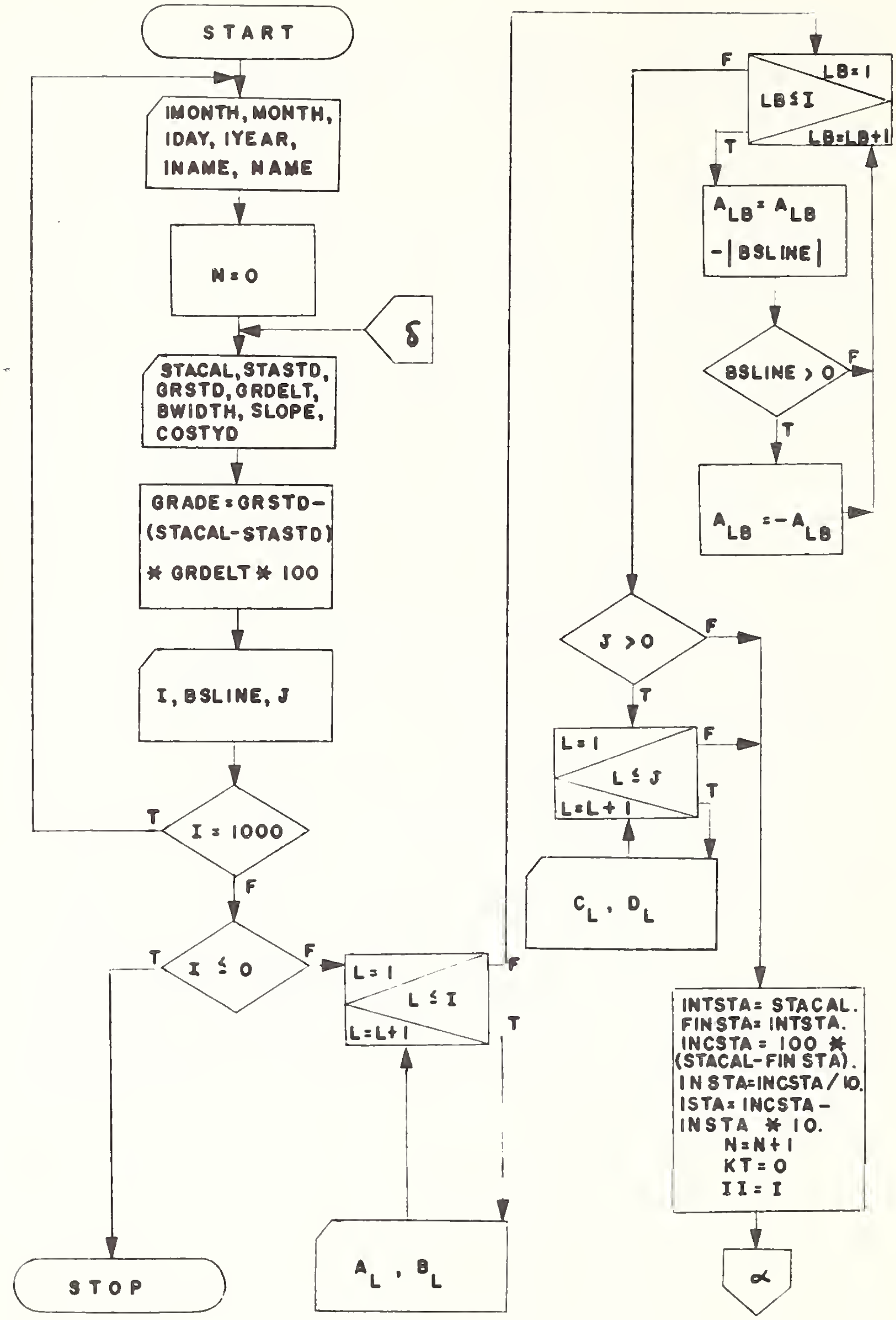
```
    LOCATING OPEN CHANNELS- COMPUTER PROGRAM FOR CALCULATING
                            EXCAVATION VOLUMES

    NR = CARD READER UNIT NUMBER
    NP = PRINTER UNIT NUMBER
    DIMENSION A(75), B(75), C(50), D(50), E(75), IMAGE(1428), CTRI(15)
   1, CTRDOT(15), ZERO(15), HEAD(18), ORD(10), ABSC(22)
    NR = 11
    NP = 12
    DATA HEAD(1)/'    '/,HEAD(2)/'    '/,HEAD(3)/'    '/,HEAD(4)/'
   1'/,HEAD(5)/'    '/,HEAD(6)/'    '/,HEAD(7)/'    '/,HEAD(8)/'  PL'/
   2,HEAD(9)/'OTTE'/,HEAD(10)/'D CR'/,HEAD(11)/'OSS '/,HEAD(12)/'SECT'
   3/,HEAD(13)/'IONS'/,HEAD(14)/' OF '/,HEAD(15)/'AN O'/,HEAD(16)/'PEN
   4 '/,HEAD(17)/'CHAN'/,HEAD(18)/'NEL '/,ORD(1)/'    '/,ORD(2)/'    '
   5/,ORD(3)/'    '/,ORD(4)/'E L '/,ORD(5)/'E V '/,ORD(6)/'A T '/,ORD(
   67)/'I O '/,ORD(8)/'N   '/,ORD(9)/'F E '/,ORD(10)/'E T '/,ABSC(1)/'
   7    '/,ABSC(2)/'    '/,ABSC(3)/'    '/,ABSC(4)/'  DI'/,ABSC(5)/'ST
   8AN'/,ABSC(6)/'CE L'/,ABSC(7)/'EFT '/,ABSC(8)/'(FT.'/,ABSC(9)/')
   9'/,ABSC(10)/'    '/,ABSC(11)/'    '/,ABSC(12)/'    '/,ABSC(13)/'
   1C '/,ABSC(14)/'    '/,ABSC(15)/'    '/,ABSC(16)/'    '/,ABSC(17)/'
   2    '/,ABSC(18)/'DIST'/,ABSC(19)/'ANCE'/,ABSC(20)/' RIG'/,ABSC(21)
   3/'HT ('/,ABSC(22)/'FT.)'/
010 READ (NR, 1) IMONTH, MONTH, IDAY, IYEAR, INAME, NAME
  1 FORMAT(2A4,2I5,2A4)
    N = 0
120 READ (NR, 2) STACAL, STASTD, GRSTD, GRDELT, BWIDTH, SLOPE, COSTYD
  2 FORMAT(8F8.2)
    GRADE = GRSTD - (STACAL - STASTD) * GRDELT * 100.
    READ (NR, 3) I, BSLINE, J
  3 FORMAT(I5,F5.1,I5)
    IF (I .EQ. 1000)  GO TO 010
    IF (I .LE. 0)  STOP
    READ (NR, 2) (A(L), B(L), L = 1, I)
    DO 020 LB = 1, I
    A(LB) = A(LB) - ABS(BSLINE)
020 IF (BSLINE .GT. 0.)  A(LB) = -A(LB)
    IF (J .GT. 0)  READ (NR, 2) (C(L), D(L), L = 1, J)
    INTSTA = STACAL
    FINSTA = INTSTA
    INCSTA = 100. * (STACAL - FINSTA)
    INSTA = INCSTA / 10
    ISTA = INCSTA - INSTA * 10
    N = N + 1
    KT = 0
    II = 1
    DO 030 L = 1, II
    III = II - L
    DO 040 K = 1, III
    IF ((A(K) .GT. A(K+1) .AND. K .EQ. 1) .OR. (A(K) .GE. A(K+1) .AND.
   1 K .NE. 1))  GO TO 040
    TEMP = A(K)
    TEMPO = B(K)
    A(K) = A(K+1)
    B(K) = B(K+1)
    A(K+1) = TEMP
    B(K+1) = TEMPO
```

```
040 CONTINUE
    K = III + 1
    IF (KT - 1)  050, 060, 030
050 IF (A(K) .LT. -BWIDTH / 2.)  GO TO 030
    IF (A(I) .GT. -BWIDTH / 2.)  GO TO 070
    KT = 1
    IF (A(K) .EQ. -BWIDTH / 2.)  GO TO 030
090 KK = I - K
    DO 080 M = 1, KK
    A(I-M+2) = A(I-M+1)
080 B(I-M+2) = B(I-M+1)
    IF (KT .EQ. 1)  A(K+1) = -BWIDTH / 2.
    IF (KT .EQ. 2)  A(K+1) = BWIDTH / 2.
    B(K+1) = (A(K+2) - A(K+1)) * (B(K+2) - B(K)) / (A(K) - A(K+2)) +
   1 B(K+2)
    I = I + 1
    IF (KT .NE. 1 .OR. A(K) .LT. BWIDTH / 2.)  GO TO 030
060 IF (A(K) .LE. BWIDTH / 2.)  GO TO 030
    KT = 2
    IF (A(K) .NE. BWIDTH / 2.)  GO TO 090
030 CONTINUE
    DO 100 L = 1, I
    IF (ABS(A(L)) .LE. BWIDTH / 2.)  E(L) = GRADE
100 IF (ABS(A(L)) .GT. BWIDTH / 2.)  E(L) = GRADE + (ABS(A(L)) -
   1 BWIDTH / 2.) * SLOPE
    AINC = 0.
    AREA = 0.
    L = 0
    IF (( A(I) .GT. -BWIDTH / 2.) .OR. (A(1) .LT. BWIDTH / 2.))  GO TO
   1 070
    IF ((B(1) .LE. E(1)) .AND. (B(I) .LE. E(I)))  GO TO 110
070 WRITE (NP, 4) N, INTSTA, INSTA, ISTA
  4 FORMAT(1H1,55X,4HPAGE,I4//////////////////////51X,7HSTATION,I6,1H+,
   1I2//39X,41HFIELD NOTES NOT TAKEN SUFFICIENT DISTANCE//50X,19HAREA
   2 NOT CALCULATED//20X,79HVOLUME AT NEXT STATION IS BETWEEN THE LAST
   3 STATION AND THE NEXT PLOTTED SECTION )
    GO TO 120
110 L = L + 1
    IF (B(L) .LE. E(L))  GO TO 130
    Z = I.0
    IF (A(L) .EQ. A(L-1))  GO TO 140
    IF (A(L) .GE. BWIDTH / 2. .OR. A(L) .LT. -BWIDTH / 2.)  GO TO 150
    X = (B(L) - E(L)) * (A(L-1) - A(L)) / (B(L) - B(L-1))
    GO TO 160
150 IF (B(L) .NE. B(L-1))  GO TO 170
    X = (B(L) - E(L)) / SLOPE
    GO TO 160
170 IF (A(L) .LT. 0.)  Z = -1.0
    X = (-A(L-1) * (B(L) - B(L-1)) / (A(L-1) - A(L)) - B(L-1) - BWIDTH
   1 * SLOPE / 2.0 + GRADE) / ((B(L) - B(L-1)) / (A(L) - A(L-1)) -
   2 SLOPE * Z) - A(L)
160 AINC = X * (B(L) - E(L)) / 2.0
200 AREA = AREA + AINC
140 L = L + I
    IF (L .GT. I)  GO TO 180
    IF (B(L) .LT. E(L))  GO TO 190
```

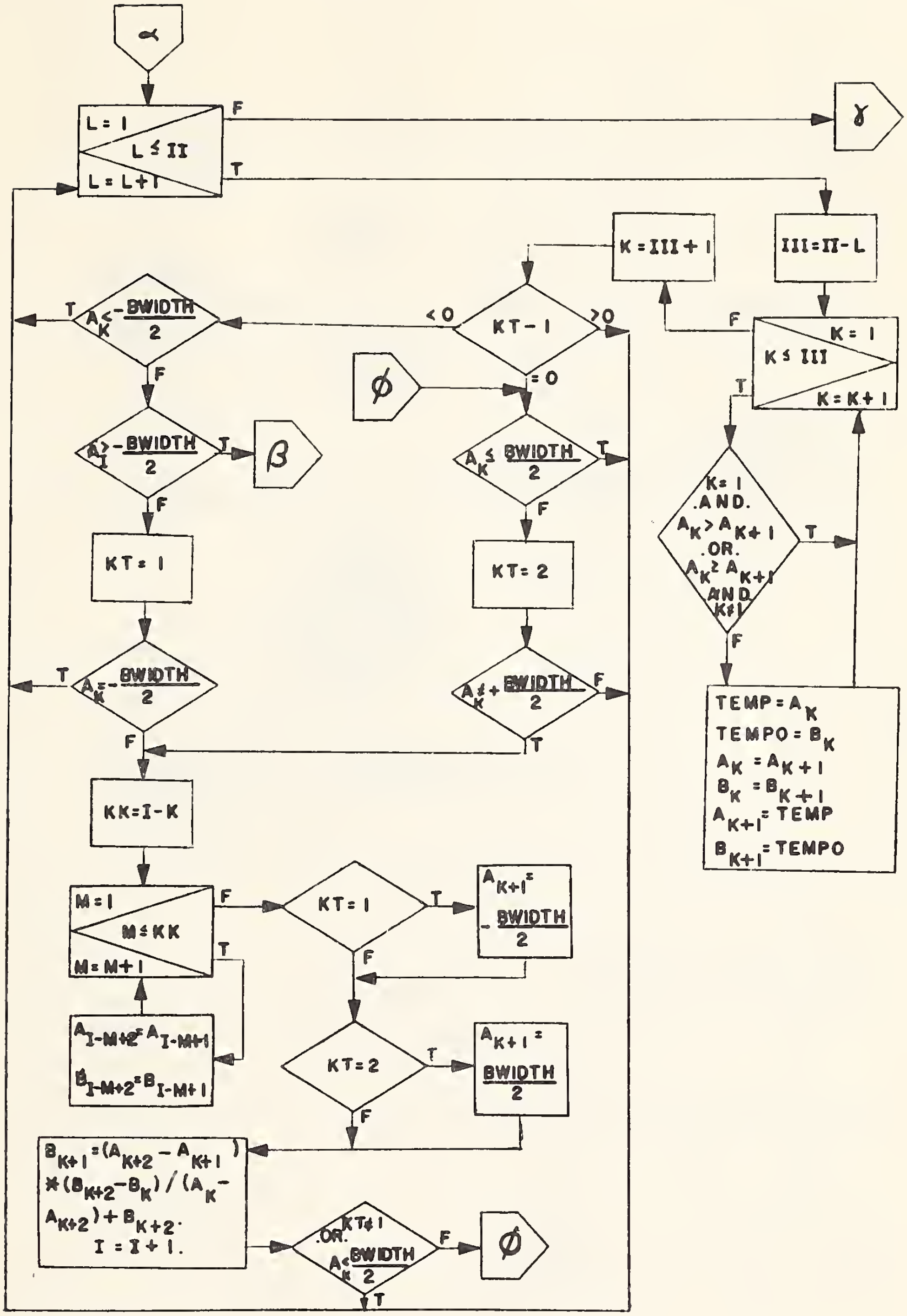
## A. Program Source Statements (Cont.)

```
      X = A(L-1) - A(L)
      AINC = X * (B(L-1) - E(L-1) + B(L) - E(L)) / 2.0
      GO TO 200
  190 IF (A(L) .EQ. A(L-1) .OR. B(L-1) .EQ. E(L-1))  GO TO 130
      IF (A(L) .GE. BWIDTH / 2. .OR. A(L) .LT. -BWIDTH / 2.)  GO TO 210
      X = (B(L-1) - E(L-1)) * (A(L-1) - A(L)) / (B(L-1) - B(L))
      GO TO 220
  210 IF (A(L) .LT. 0.)  Z = -1.0
      IF (B(L) .NE. B(L-1))  GO TO 230
      X = (B(L-1) - E(L-1)) / SLOPE
      GO TO 220
  230 X = -(-A(L-1) * (B(L) - B(L-1)) / (A(L-1) - A(L)) - B(L-1) -
     1 BWIDTH * SLOPE / 2.0 + GRADE) / ((B(L) - B(L-1)) / (A(L) -
     2 A(L-1)) - SLOPE * Z) + A(L-1)
  220 AINC = X * (B(L-1) - E(L-1)) / 2.0
      AREA = AREA + AINC
  130 IF (AREA .EQ. 0.)  LK = L
      IF (L .LT. I)  GO TO 110
  180 VOLUME = (AREA + AREAFI) / 2.0 * ABS(CALSTA - STACAL) * 100. / 27.
      IF (N .EQ. 1)  VOLUME = 0.0
      COSTFI = VOLUME * COSTYD
      IF (N .EQ. 1)  RUNTOT = 0.0
      RUNTOT = RUNTOT + COSTFI
  250 IF (B(L-1) .GE. E(L-1))  GO TO 240
      L = L - 1
      IF (L .GT. 1)  GO TO 250
  240 IGRADE = GRADE / 10.0
      GRADPT = 10 * IGRADE + 40
      GRADPL = 10 * IGRADE - 10
      XSCALE = 100.
      IF ((A(LK) .LE. 50.) .AND. (A(L) .GE. -50.))  XSCALE = 50.
      IF ((A(LK) .LE. 25.) .AND. (A(L) .GE. -25.))  XSCALE = 25.
      DO 260 M = 1, 14
      ZERO(M) = 0.
      CTRM = M - 1
      CTRI(M) = GRADPT - 4. * CTRM
  260 CTRDOT(M) = GRADPT - 4. * CTRM - 2.
      CALL PLOTA (IMAGE, -XSCALE, XSCALE, GRADPL, GRADPT, 0)
      CALL PLOTB (ZERO, CTRI, 4H000I, 13)
      CALL PLOTB (ZERO, CTRDOT, 4H000., 13)
      CALL PLOTB (C, D, 4H000A, J)
      CALL PLOTB (A(LK), E(LK), 4H000D, L + 1 - LK)
      CALL PLOTB (A, B, 4H000E, I)
      CALL PLOTC (HEAD, 18, ORD, 10, ABSC, 22)
      WRITE (NP, 5) INAME, NAME, IMONTH, MONTH, IDAY, IYEAR, INTSTA,
     1 INSTA, ISTA, GRADE, AREA, VOLUME, COSTFI, RUNTOT, N
    5 FORMAT( /4X,63HSTATION    GRADE    X-SEC.  EXCAVATION  EXCAVATION
     1 EXPENSE    ,2A4,42H PROJECT    D= DESIGN   SEC.    PROGRAM BY/6X,
     261HNO.        FT.      SQ.FT.     CU.YD.    SECTION  CUMULATIVE    ,2
     3A4,I3,1H,,I4,4X,30HA= AS BUILT SEC.    J.R.HOOVER/I8,1H+,2I1,3(1X,
     4F8.2,1X),3X,1H$,F6.1,2X,1H$,F9.2,4X,11HX-SEC. PAGE,I5,4X,28HE= EXI
     5STING SEC.       O.S.U.)
      AREAFI = AREA
      CALSTA = STACAL
      GO TO 120
      END
```

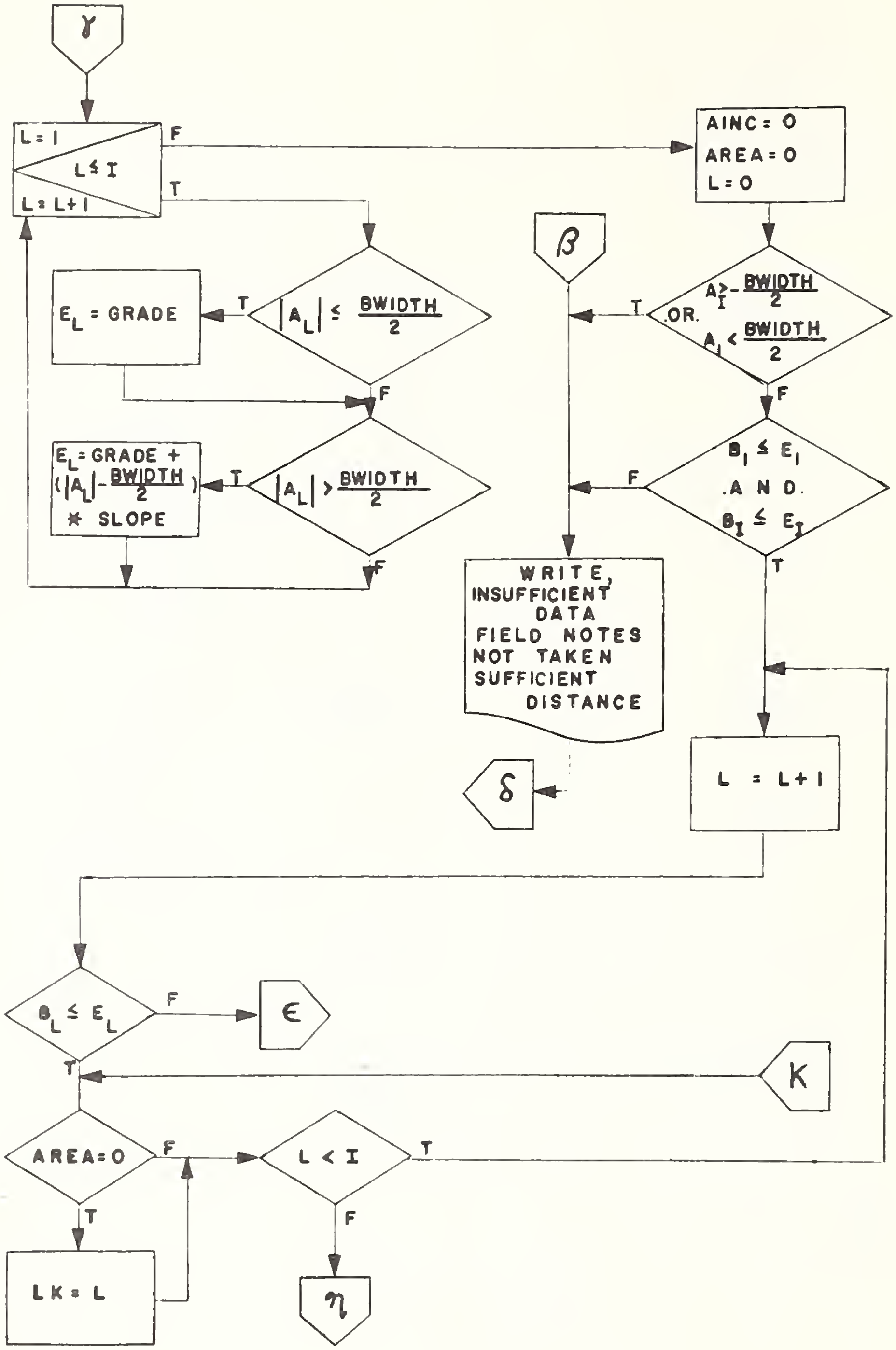
B. Program Flow Chart. Sequence 1.



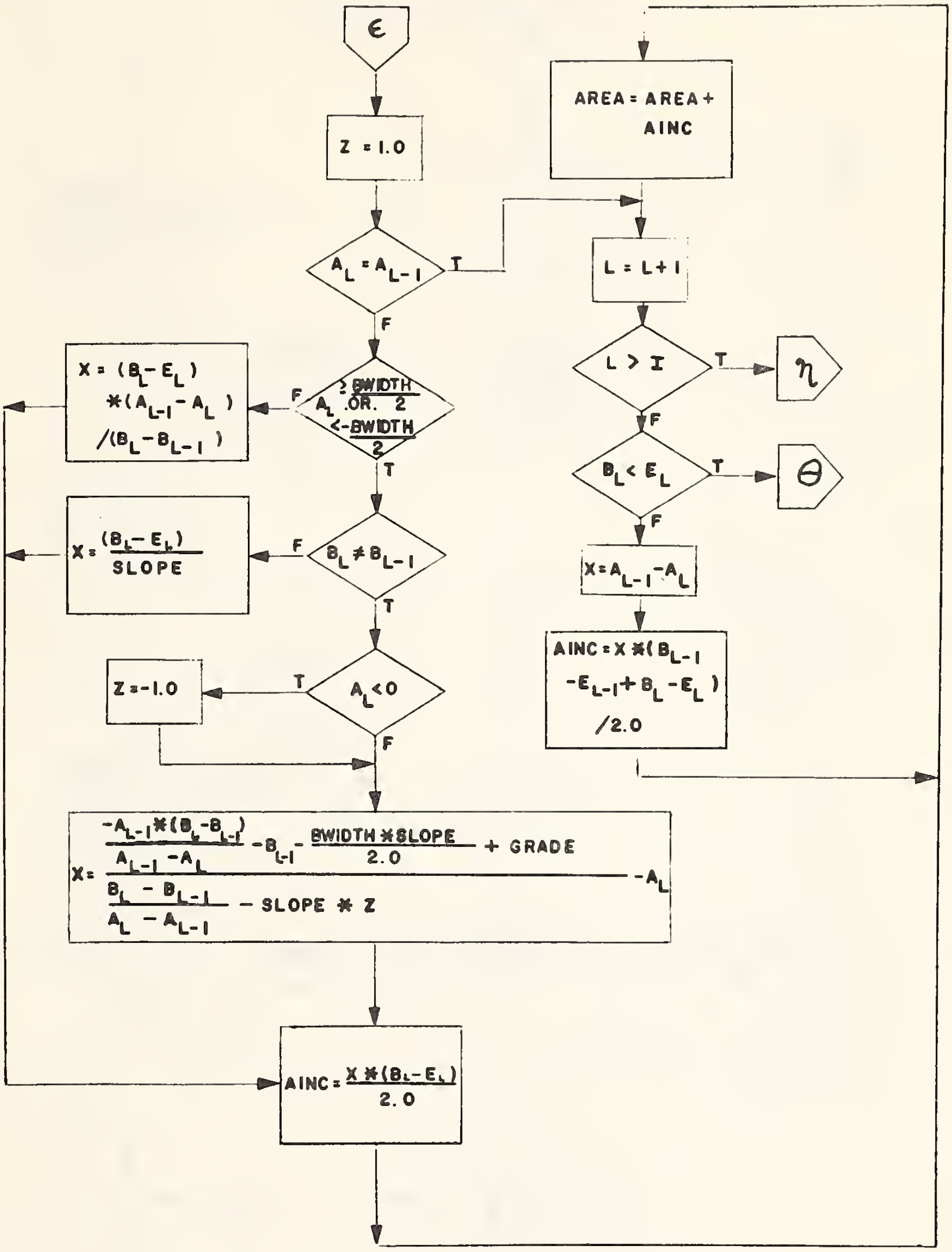
B. Program Flow Chart. Sequence 2.



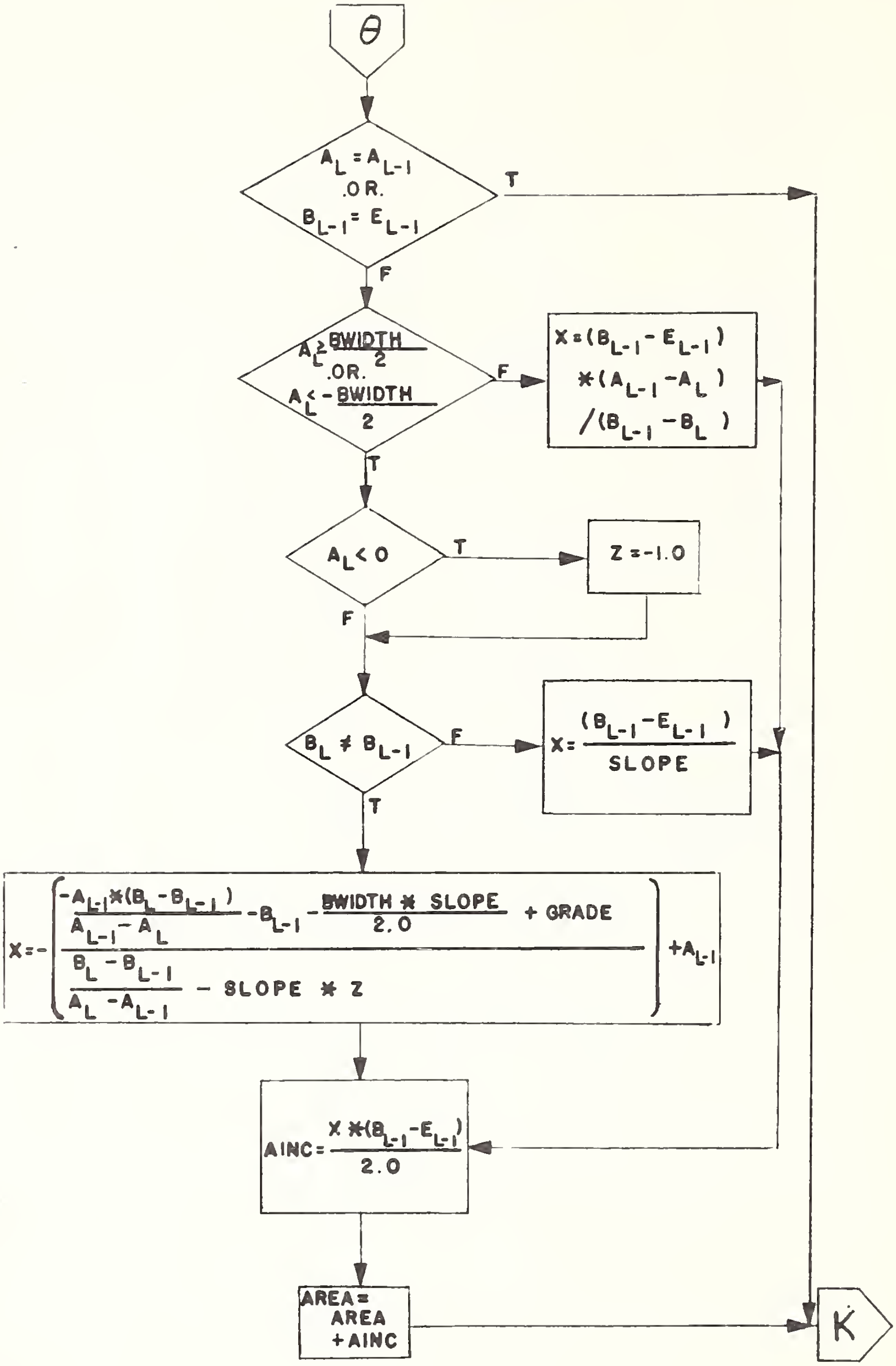
## B. Program Flow Chart. Sequence 3.



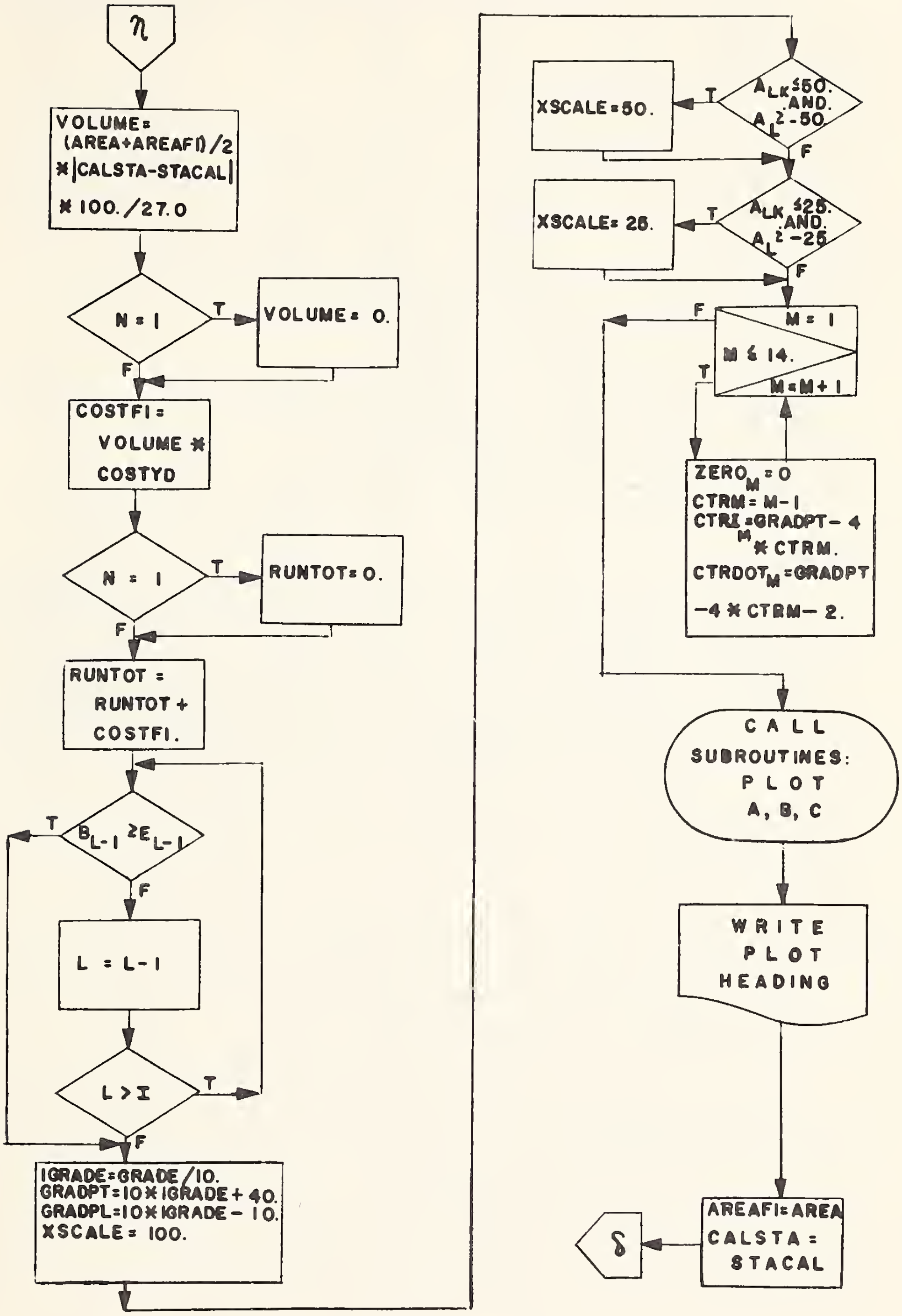
B. Program Flow Chart. Sequence 4.


ε
Z = 1.0
A_L = A_L-1
T
F
X = (B_L - E_L) *(A_L-1 - A_L) /(B_L - B_L-1)
A_L ≥ BWIDTH/2 .OR. < -BWIDTH/2
X = (B_L - E_L)/SLOPE
B_L ≠ B_L-1
Z = -1.0
A_L < 0
X = ((-A_L-1 *(B_L - B_L-1))/(A_L-1 - A_L) - B_L-1 - (BWIDTH *SLOPE)/2.0 + GRADE)/((B_L - B_L-1)/(A_L - A_L-1) - SLOPE * Z) - A_L
AINC = X *(B_L - E_L)/2.0
AREA = AREA + AINC
L = L+1
L > I
η
B_L < E_L
θ
X = A_L-1 - A_L
AINC = X *(B_L-1 - E_L-1 + B_L - E_L) /2.0

B. Program Flow Chart. Sequence 5.


θ
$A_L = A_{L-1}$ .OR. $B_{L-1} = E_{L-1}$
T
F
$A_L \geq \frac{BWIDTH}{2}$ .OR. $A_L < -\frac{BWIDTH}{2}$
F
$X = (B_{L-1} - E_{L-1}) * (A_{L-1} - A_L) / (B_{L-1} - B_L)$
T
$A_L < 0$
T
$Z = -1.0$
F
$B_L \neq B_{L-1}$
F
$X = \frac{(B_{L-1} - E_{L-1})}{SLOPE}$
T
$X = -\left(\frac{\frac{-A_{L-1} * (B_L - B_{L-1})}{A_{L-1} - A_L} - B_{L-1} - \frac{BWIDTH * SLOPE}{2.0} + GRADE}{\frac{B_L - B_{L-1}}{A_L - A_{L-1}} - SLOPE * Z}\right) + A_{L-1}$
$AINC = \frac{X * (B_{L-1} - E_{L-1})}{2.0}$
AREA = AREA + AINC
K

B. Program Flow Chart. Sequence 6.



η
VOLUME = (AREA+AREAFI)/2 * |CALSTA-STACAL| * 100./27.0
N = 1
T
VOLUME = 0.
F
COSTFI = VOLUME * COSTYD
N = 1
T
RUNTOT = 0.
F
RUNTOT = RUNTOT + COSTFI.
T
B_{L-1} ≥ E_{L-1}
F
L = L-1
L > I
T
F
IGRADE = GRADE/10.
GRADPT = 10 * IGRADE + 40.
GRADPL = 10 * IGRADE - 10.
XSCALE = 100.
A_LK ≤ 50. .AND. A_L ≥ -50.
T
XSCALE = 50.
F
A_LK ≤ 25. .AND. A_L ≥ -25
T
XSCALE = 25.
F
F
M = 1
M ≤ 14.
M = M + 1
T
ZERO_M = 0
CTRM = M-1
CTRI_M = GRADPT - 4 * CTRM.
CTRDOT_M = GRADPT -4 * CTRM - 2.
CALL SUBROUTINES: PLOT A, B, C
WRITE PLOT HEADING
AREAFI = AREA
CALSTA = STACAL
δ

## C. Input Data Specifications

The data deck for the open channel computer program consists of five types of data cards, sequenced as follows:

*Card Type, Variable Labels, and Descriptions*

1. IMONTH, IDAY, IYEAR, NAME

   The month, day, year, and project name, respectively. Card format - (2A4, 2I5, 2A4).

2. STACAL, STASTD, GRSTD, GRDELT, BWIDTH, SLOPE, COSTYD

   STACAL – station where calculation is to be made.
   STASTD – station at last grade change.
   GRSTD – grade elevation at last grade change.
   GRDELT – feet change in grade elevation/foot length.
   BWIDTH – bottom width of channel in feet.
   SLOPE – tangent (decimal) of side slope angle.
   COSTYD – excavation cost per cubic yard in dollars.
   Card format – (8F8.2).

3. L,BSLINE, J

   L - number of survey data points for each existing cross section. Submit additional data sets by setting L = 1,000 and following with card type 1. To stop the program, set L = −1.

   BSLINE - baseline to proposed centerline distance. Changing BSLINE shifts the channel location. If baseline is on left side of channel when looking upstream, set BSLINE = negative distance. This reverses the cross section plot.

   J - number of as-built survey data points per cross section. Leave blank to omit as-built data.

   Card format - (I5, F5.1, I5).

4. $A_i$, $B_i$, $A_{i+1}$, $B_{i+1}$, $A_{i+2}$, $B_{i+2}$, $A_{i+3}$, $B_{i+3}$, $A_{i+4}$, $B_{i+4}$

   A - distance from baseline, B - elevation of point at A.
   Continue field notes on card type 4 as needed.
   Card format - (8F8.2).

5. Add card type 5 if as-built survey data for constructed channel are to be plotted. Follow card format number 4.

   Repeat cards 2 through 5 for each new station.

## D. Input Data Example

```
NOVEMBER    1 1964MCGURER.
   50.00   50.00   85.70  .00542     4.0   0.66     0.30
    8 48.0
    0.0    90.0    15.0    89.6    30.0    87.2    41.0    87.1
   44.0    86.2    50.0    85.7    57.0    86.9    68.0    87.7
   49.00   50.00   85.70  .00542     4.0   0.66     0.30
    6 50.0
   -6.0    90.2    25.0    88.3    35.0    89.4    50.0    87.5
   65.0    89.7    90.0    89.7      .0      .       .0      .
   48.00   50.00   85.70  .00542     4.0   0.66     0.30
    8 63.0
    0.0    91.3    26.0    90.1    39.0    89.5    54.0    89.6
   60.0    87.4    63.0    87.4    71.0    89.9    83.0    89.3
   47.00   50.00   85.70  .00542     4.0   0.66     0.30
    4 63.0
    0.0    92.7    45.0    90.8    63.0    87.5    75.0    90.8

 1000
NOVEMBER    1 1964MCGURER.
   50.00   50.00   85.70  .00542     4.0   0.66     0.30
    8 48.0
    0.0    90.0    15.0    89.6    30.0    87.2    41.0    87.1
   44.0    86.2    50.0    85.7    57.0    86.9    68.0    87.7
   49.00   50.00   85.70  .00542     4.0   0.66     0.30
    6 52.0
   -6.0    90.2    25.0    88.3    35.0    89.4    50.0    87.5
   65.0    89.7    90.0    89.7      .0      .       .0      .
   48.00   50.00   85.70  .00542     4.0   0.66     0.30
    8 61.0
    0.0    91.3    26.0    90.1    39.0    89.5    54.0    89.6
   60.0    87.4    63.0    87.4    71.0    89.9    83.0    89.3
   47.00   50.00   85.70  .00542     4.0   0.66     0.30
    4 63.0
    0.0    92.7    45.0    90.8    63.0    87.5    75.0    90.8

   -1
```